

What is claimed is:

1. A particle analyzing apparatus for analyzing a sample comprising:
an elongated capillary channel having a predetermined internal cross-sectional
area,
5 a pump connected to one end of the capillary channel for drawing sample into
the other end of the capillary channel and through the capillary channel to cause
particles to flow along said capillary channel,
a light source for illuminating a predetermined analyzing volume of sample in
the capillary channel,
10 at least one detector for detecting fluorescent light emitted by particles in said
volume excited by the illumination impinging upon particles in said predetermined
volume.
2. A particle analyzing apparatus as in claim 1 in which said capillary
15 channel is in a capillary tube.
3. A particle analyzing apparatus as in claim 2 in which the capillary
channel is cylindrical.
- 20 4. A particle analyzing apparatus as in claim 2 in which the capillary
channel is rectangular.
5. A particle analyzing apparatus as in claim 1 including a detector for
detecting all particles flowing along said capillary tube.
25
6. A particle analyzing apparatus for analyzing a sample as in claim 5 in
which said particle detector detects light scattered by particles in said predetermined
analyzing volume.
- 30 7. A particle analyzing apparatus as in claim 5 in which said detector
detects a change in impedance caused by said flowing particles.

8. A particle analyzing apparatus for analyzing a sample as in claim 1 in which said detector for detecting fluorescent light includes a lens for intercepting fluorescent light, and

5 a slit located at the focus of the lens for blocking unwanted light from said detector.

9. A particle analyzing apparatus for analyzing a sample as in claim 8 including a particle detector for detecting light scattered by the particles in said analyzing volume.

10

10. A particle analyzing apparatus for analyzing a sample as in claim 6 or 9 in which said particle detector includes a beam blocker for blocking direct light whereby said detector receives only scattered light.

15 11. A particle analyzing apparatus for analyzing a sample as in claims 6 or 9 in which the particle detector is an off-axis detector.

12. A particle analyzing apparatus for analyzing a sample comprising a capillary tube having a predetermined internal cross-section having one end
20 suspended,

a pump connected to one end of the capillary tube for drawing sample into the tube through the suspended end of the capillary tube,

a source of light,

25 an optical system for receiving and focusing the light from said source to form and direct a thin rectangular beam through said capillary tube to define an analyzing volume in said capillary tube, said capillary tube selected to have a diameter which causes substantially all particles to be singulated as they pass through said analyzing volume,

30 at least one detector for detecting those particles in which fluorescence is excited by said beam, and

a detector for detecting all particles which pass through said analyzing volume.

13. A particle analyzing apparatus as in claim 12 including a plurality of detectors for detecting particles which fluoresces at different wavelengths.

14. A particle analyzing apparatus as in claim 12 in which said particle
5 detector detects light scattered by said particles.

15. A particle analyzing apparatus as in claim 12 in which said particle detector detects the electrical impedance of said particles.

16. A particle analyzing apparatus as in claim 12 in which the capillary
10 tube internal cross-section is rectangular.

17. A particle analyzing apparatus as in claim 12 in which the capillary
15 tube internal cross-section is cylindrical.

18. A particle analyzing apparatus as in claim 12 in which the optical
system is configured to form a thin, wide rectangular beam at the capillary to
illuminate a small analyzing volume defined by the thickness of the beam in the
direction of flow of said fluid and by the internal walls of the capillary in the other
20 direction.

19. A particle analyzing apparatus as in claim 14 including a beam blocker
for blocking the direct transmission of illumination from said beam to the particle
detector.

25

20. A particle analyzing apparatus comprising:
a capillary tube of predetermined internal cross-section selected such as to
singulate particles flowing therethrough,
a tee, a pump connected to one arm of said tee,
30 a capillary conduit extending from another arm of said tee and connected to
one end of the capillary tube,

a discharge conduit and a valve connected to the other arm of said tee,
whereby when the valve is closed, the pump can draw fluid from the other end of the
capillary through said capillary, and when the valve is opened the pump can discharge
fluid sample previously drawn through the capillary,

5 a light source for illuminating a predetermined analyzing volume of fluid in
said capillary tube,

at least one detector for detecting fluorescent light emitted by particles flowing
through said volume in response to said illumination, and

a detector for detecting particles which flow through said analyzing volume.

10

21. A particle analyzing apparatus as in claim 19 in which said at least one
detector means for detecting fluorescent light emitted by particles in said volume
includes:

means for gathering fluorescent light emitted by particles in said volume,

15 a beam splitter for receiving said gathered light and reflecting light above a
predetermined wavelength and passing light below said predetermined wavelength,

a first detector for receiving the transmitted light and providing a first output
signal for particles tagged to emit light below said predetermined wavelength,

20 a second detector for receiving the reflected light and providing a second
output signal for particles tagged to emit light above said predetermined wavelength.

22. A particle analyzing apparatus as in claim 21 in which said
predetermined wavelength is 620 nm, said light below said predetermined wavelength
is 580 nm, and above said predetermined wavelength is 675 nm.

25

23. A particle analyzing apparatus as in claim 22 including a filter
interposed between the beam splitter and each detector for passing light at 580 nm and
675 nm, respectively.

30 24. A particle analyzing apparatus as in claim 21 in which said means for
gathering the fluorescent light emitted by particles comprises:

a lens for collecting the light, and

a slit positioned in front of said at least one detector to define the analyzing volume observed by said detector.

25. A particle counting apparatus as in claim 20 or 21 in which the
5 diameter of said discharge conduit is substantially larger than the diameter of the capillary tube.

26. Method of detecting particles in a sample fluid which comprises the steps of:

10 providing a capillary tube of predetermined internal cross-section with a suspended end,

drawing the sample fluid through the suspended end of said capillary tube and through the capillary tube to cause substantial singulation of the particles,

focusing a beam of light onto the capillary tube to illuminate particles in an
15 analyzing volume bounded by the walls in one direction and the beam size in the other direction, and

detecting fluorescent light emitted by tagged particles in response to the illumination of said volume, and providing an output signal.

20 27. The method of claim 26 including the additional step of detecting light scattered by said particles as they travel through said volume and providing an output signal.

28. The method of claim 26 including the additional step of processing
25 said output signals and identifying the particles and their concentration.

29. A particle analyzing apparatus for analyzing a sample comprising:
an elongated capillary tube having a predetermined internal cross-section,
a pump connected to one end of the capillary tube for drawing sample into the
30 other end of the capillary tube and through the capillary tube to cause particles to flow along said capillary tube,

a light source for illuminating a predetermined analyzing volume of sample in the capillary tube,

means for gathering a fluorescent light emitted by said particles excited by illumination impinging on the particles, and

5 at least one detector for receiving said gathered fluorescent light.

30. A particle analyzing apparatus as in claim 29 in which said gathering means comprises a fiber optic waveguide for guiding the light into the detector.

10 31. A particle analyzing apparatus as in claim 20 in which said at least one detector means for detecting fluorescent light emitted by particles in said volume includes a plurality of detectors configured to detect fluorescent light emitted at a plurality of different wavelengths.

15 32. A particle analyzing apparatus as in claim 31 in which said means for illuminating the predetermined volume illuminates the volume with light of a plurality of different wavelengths.

20 33. A particle analyzing apparatus as in claim 29 or 30 in which said light source comprises means for projecting a thin rectangular beam through the capillary.